Mechanisms for Predecessor Rain Events Ahead of Tropical Cyclones

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UAlbany CSTAR Research

- Recent UAlbany CSTAR research addresses both cool- and warm-season heavy precipitation events and forecasting problems over the Northeast U.S.:
  - Cool-season precipitation distribution associated with cutoff cyclones – Melissa Payer
  - Cool-season severe convection and high-wind events – Jonas Asuma
  - Warm-season precipitation associated with recurving and landfalling tropical cyclones (TCs), including predecessor rain events (PREs) – Benjamin Moore

UAlbany CSTAR Research

- The most up-to-date information can be found on the UAlbany/NWS CSTAR research webpage, http://cstar.cestm.albany.edu, including:
  - Presentations
  - Reports
  - Theses
  - Teletraining sessions

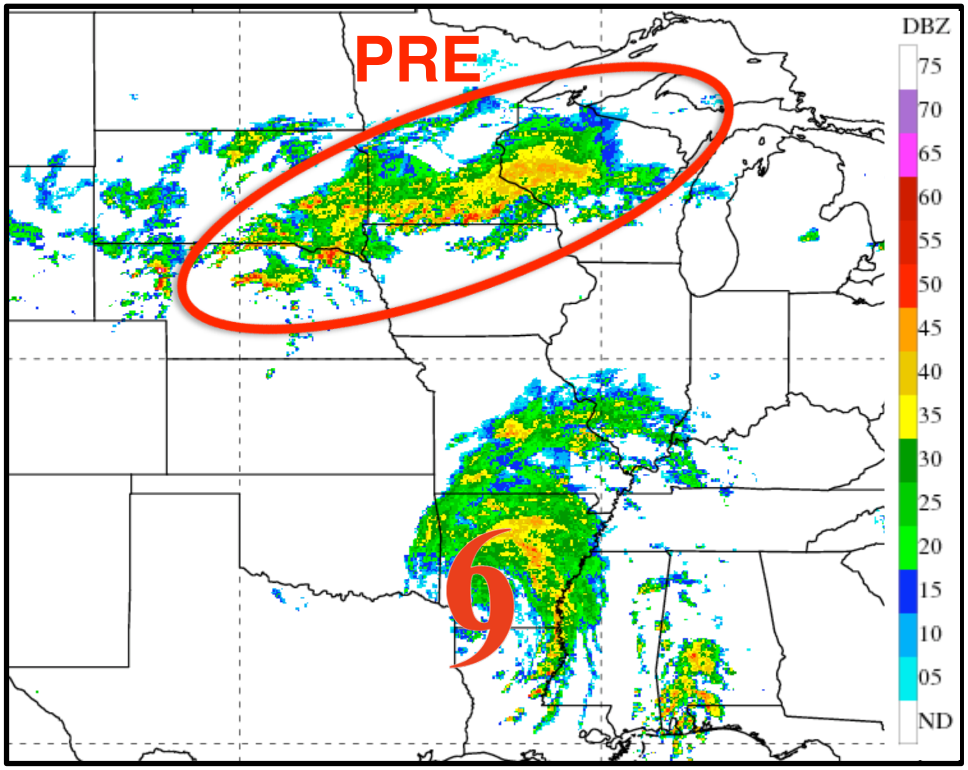
Outline

- Overview of a PRE
- PRE stratification scheme
- PRE-relative composite analysis
- PRE associated with TC Rita (2005)
- Concluding remarks

Predecessor Rain Events Ahead of Tropical Cyclones

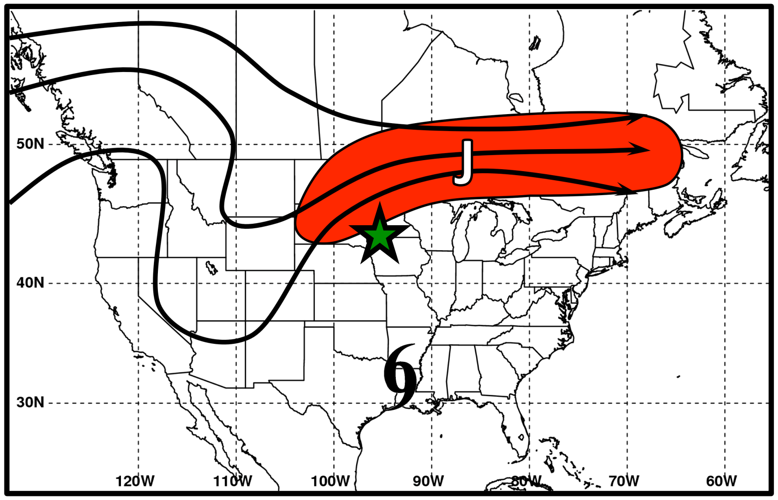
- Defined by Cote (2007) as coherent mesoscale regions of heavy rainfall [~100 mm $(24\ \mathrm{h})^{-1}$] ~1000 km downstream of landfalling and recurving tropical cyclones (TCs)
- Develop as a poleward stream of moisture from a TC interacts with a region of forcing for ascent
- Pose a substantial flash-flooding risk due to:
  - Prolonged, high precipitation rates
  - High precipitation efficiencies

PRE ahead of TC Rita
06Z 25 Sep 2005

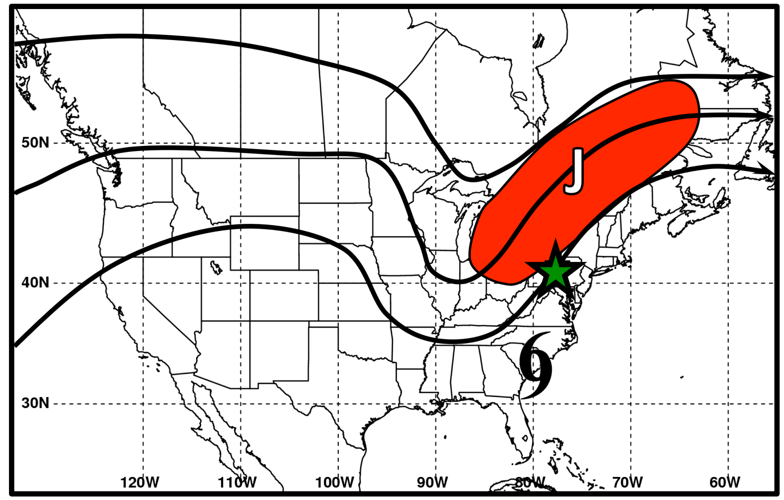


PRE Stratification Scheme

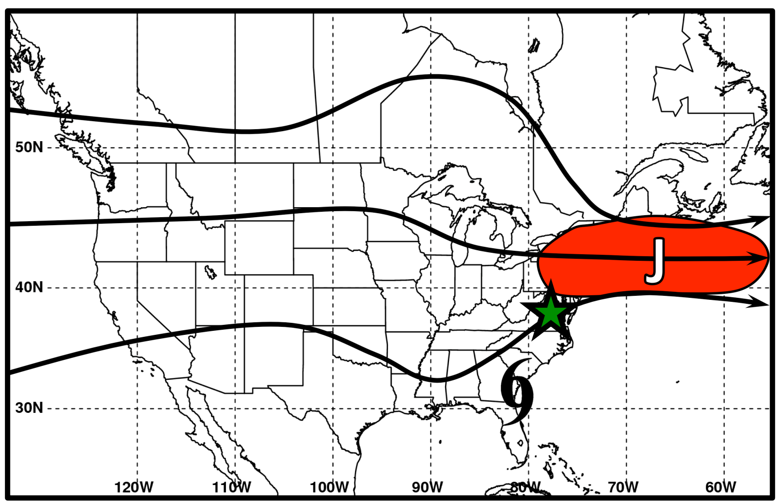
"Jet in Ridge"



"Southwesterly Jet"



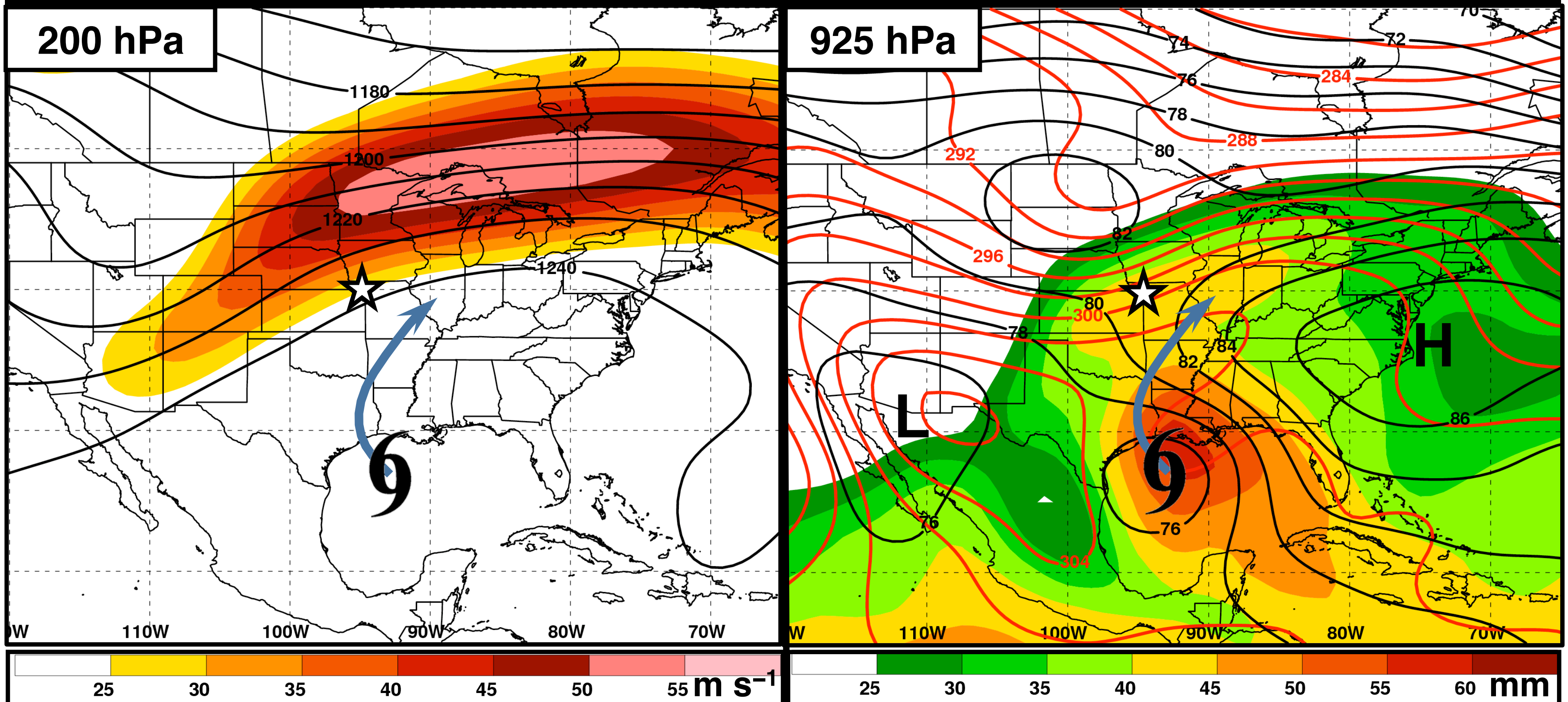
"Downstream Confluence"



PRE-Relative Composites

N = 9

“Jet in ridge” Category



200 hPa Z (dam, black), wind speed (>25 m s^{-1}, shaded)

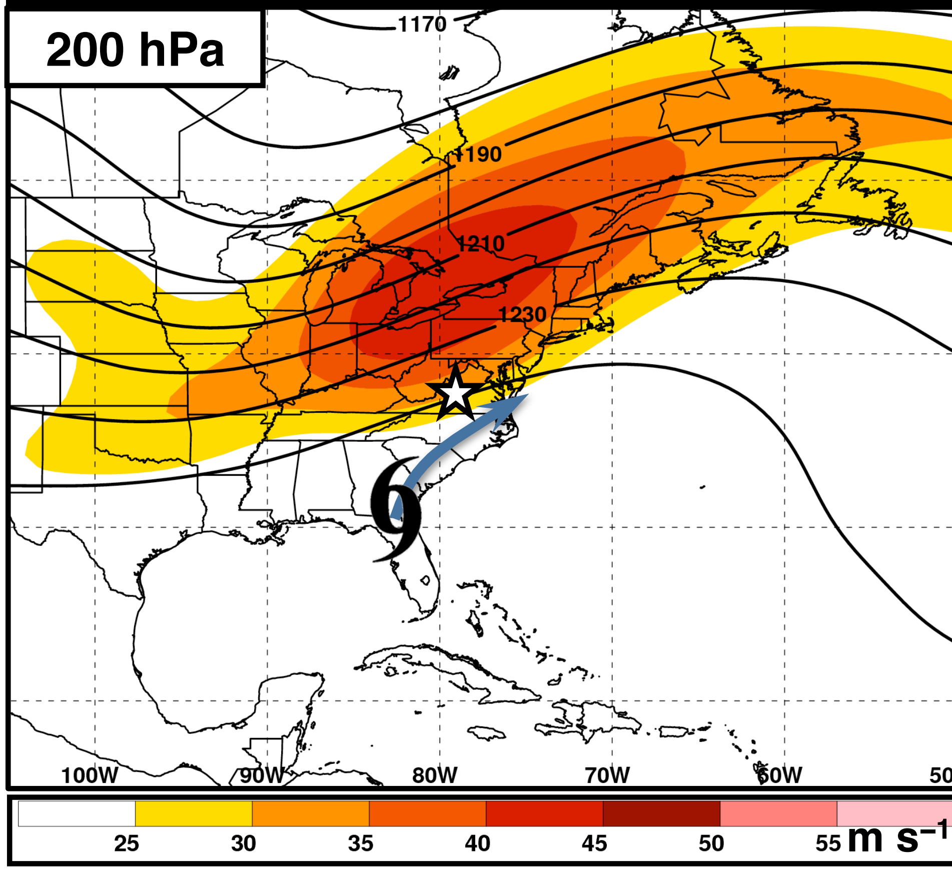
925 hPa Z (dam, black), θ (K, red), total precipitable water (>25 mm, shaded)

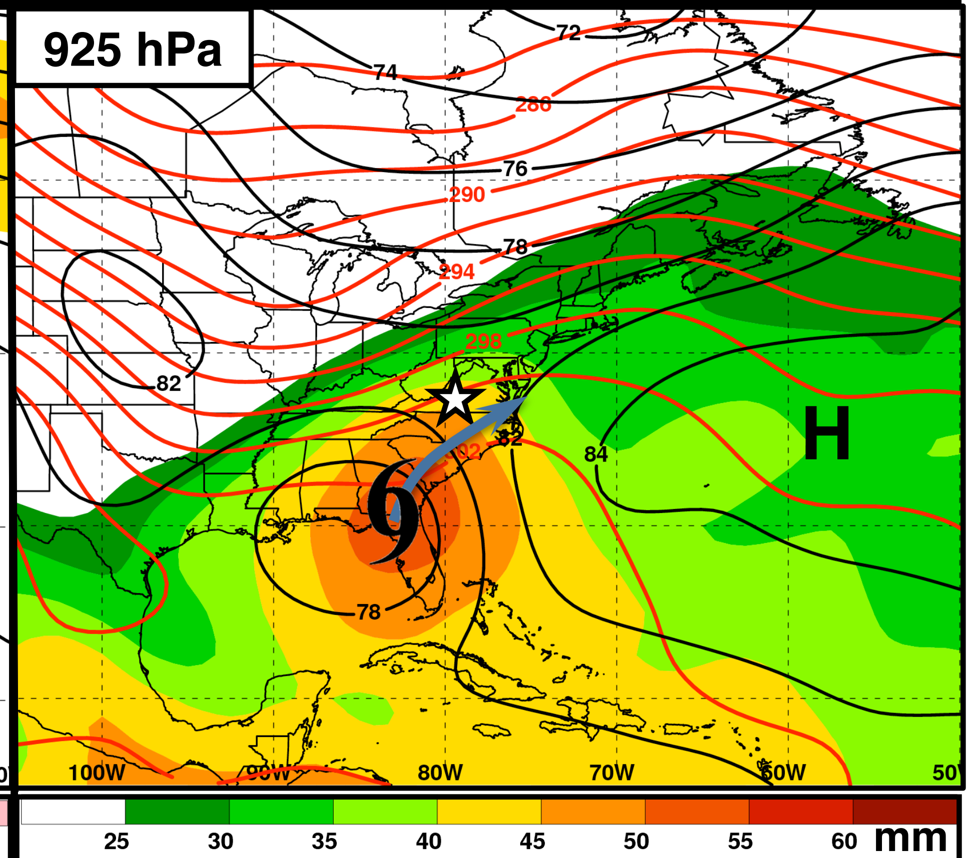
2.5° NCEP–NCAR Renalysis

PRE-Relative Composites

N = 15

“Southwesterly jet” Category





200 hPa *Z* (dam, black),
wind speed (>25 m s^{-1}, shaded)

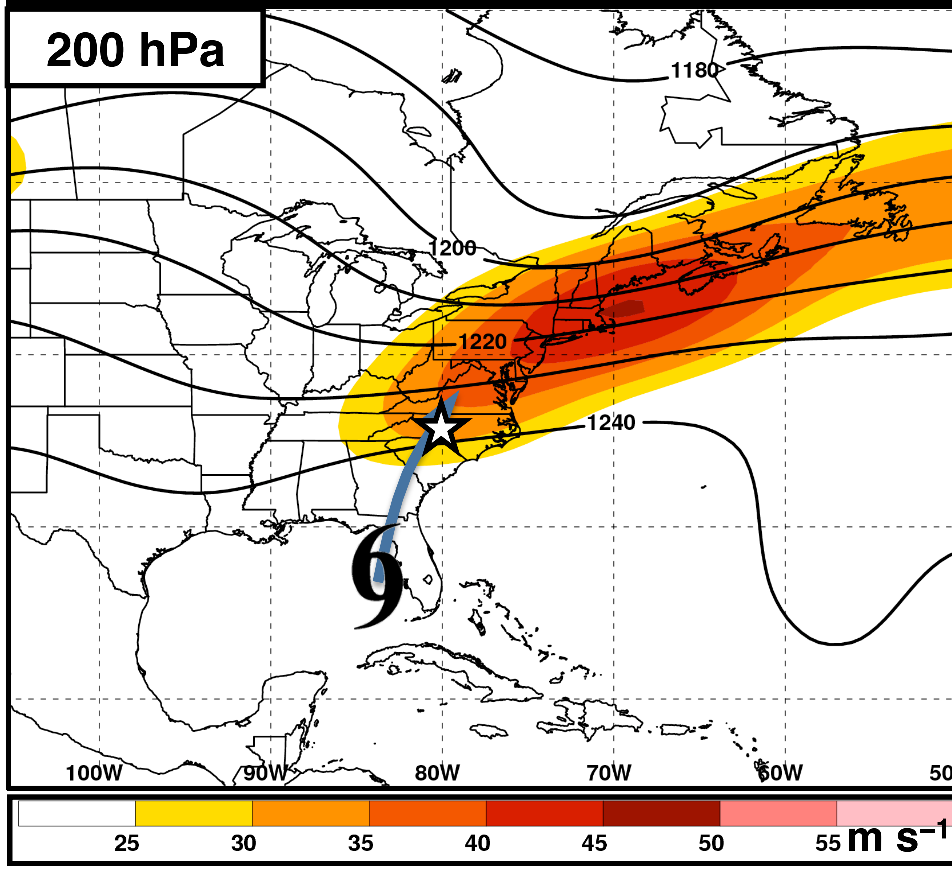
925 hPa *Z* (dam, black), θ (K, red), total precipitable water (>25 mm, shaded)

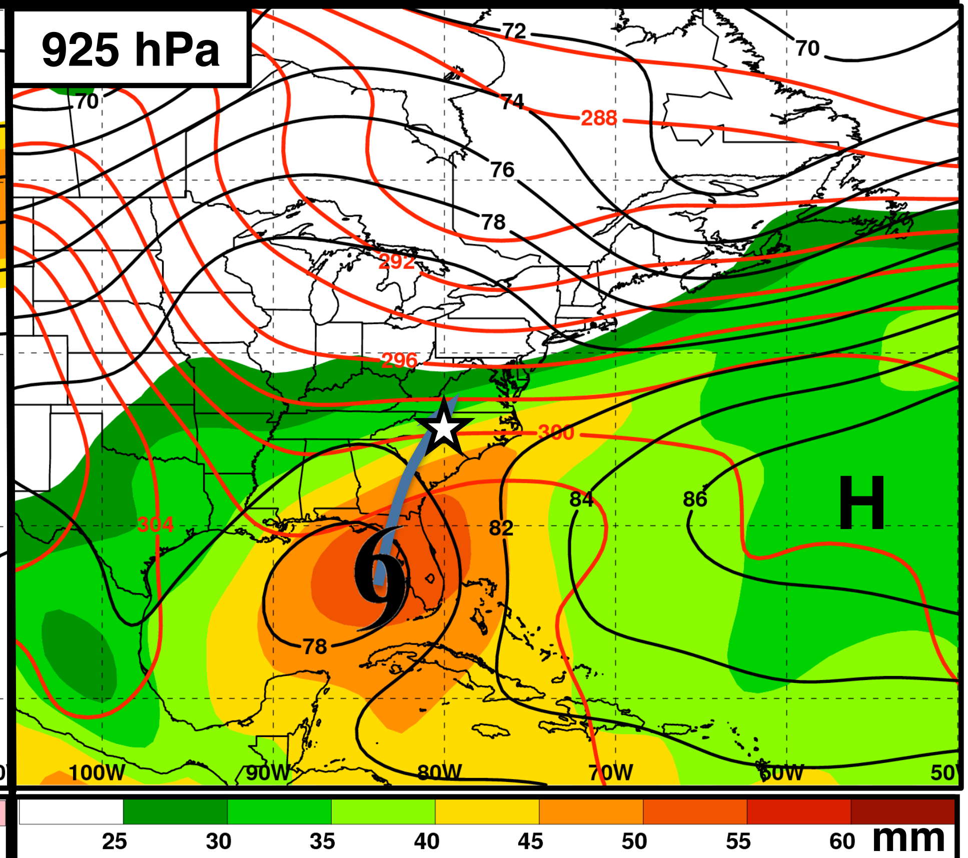
2.5° NCEP–NCAR Renalysis

PRE-Relative Composites

N = 9

"Downstream confluence" Category



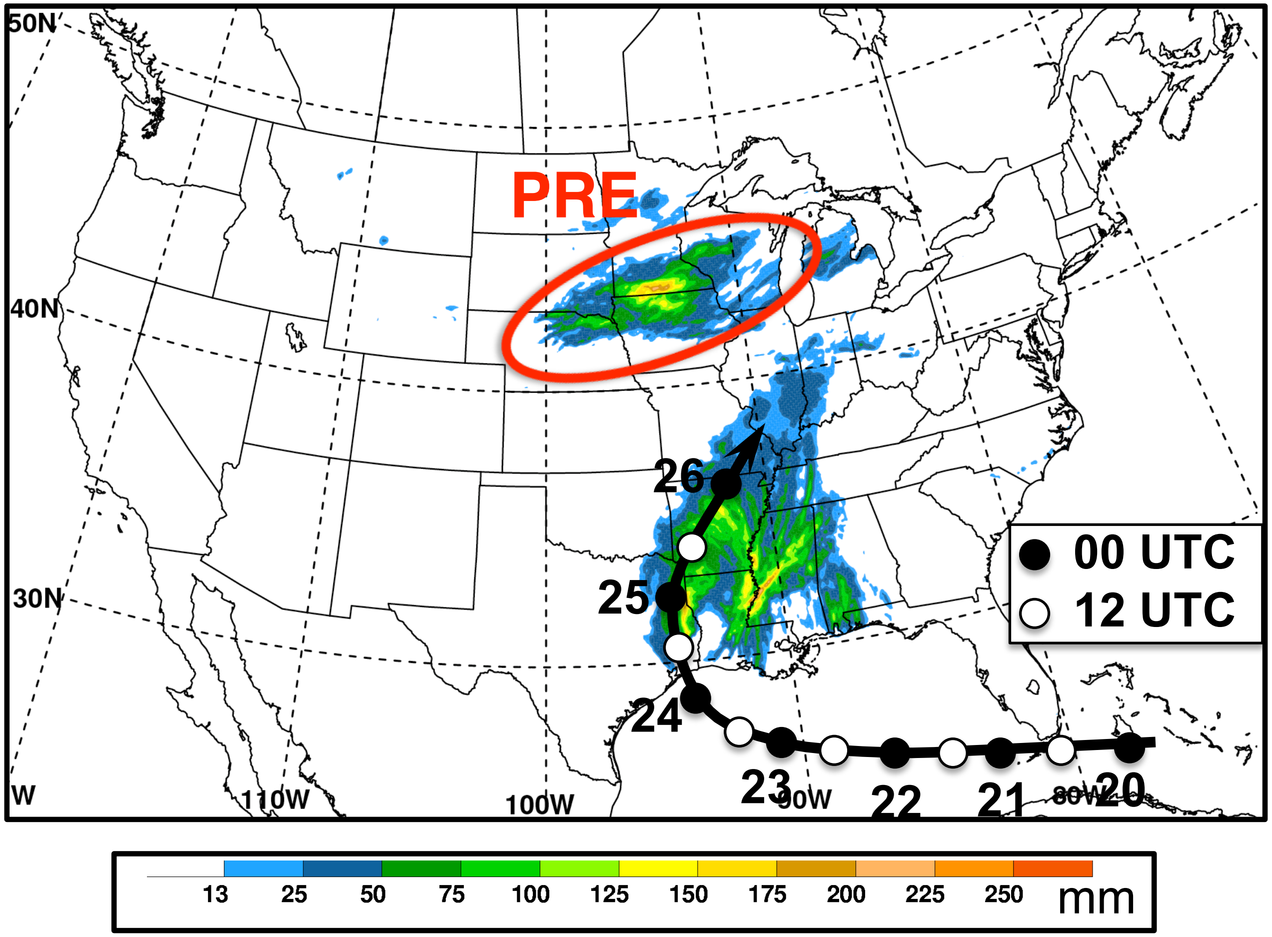


200 hPa *Z* (dam, black), wind speed (>25 m s^{-1}, shaded)

925 hPa *Z* (dam, black), θ (K, red), total precipitable water (>25 mm, shaded)

2.5° NCEP–NCAR Renalysis

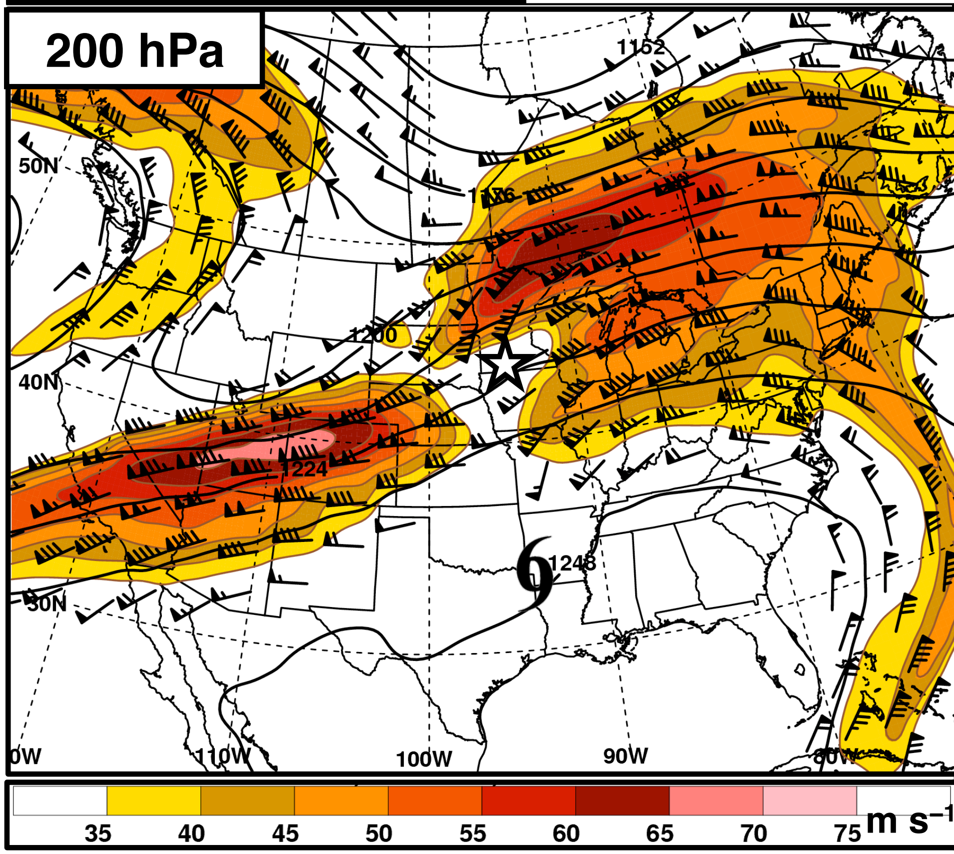
“Jet in ridge” PRE associated with TC Rita 24–25 Sep 2005

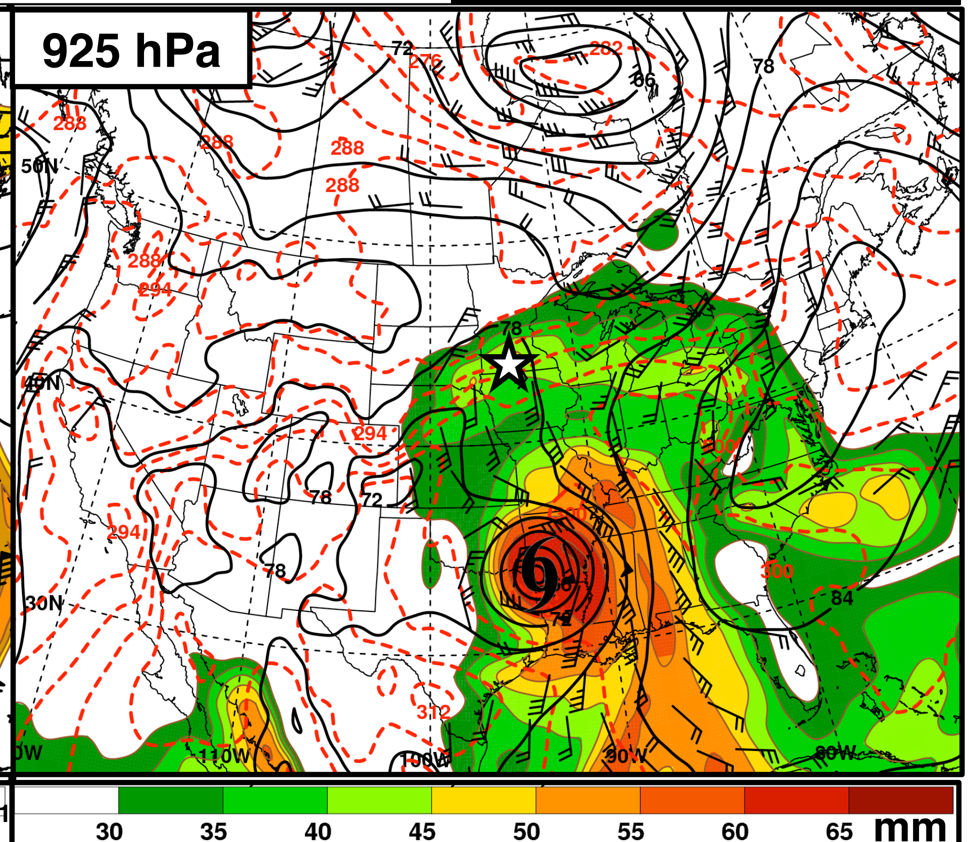


1200 UTC 24 Sep – 0000 UTC 26 Sep 2005 total precipitation (mm, shaded) generated from the NPVU QPE dataset

Synoptic Environment

0600 UTC 25 Sep 2005





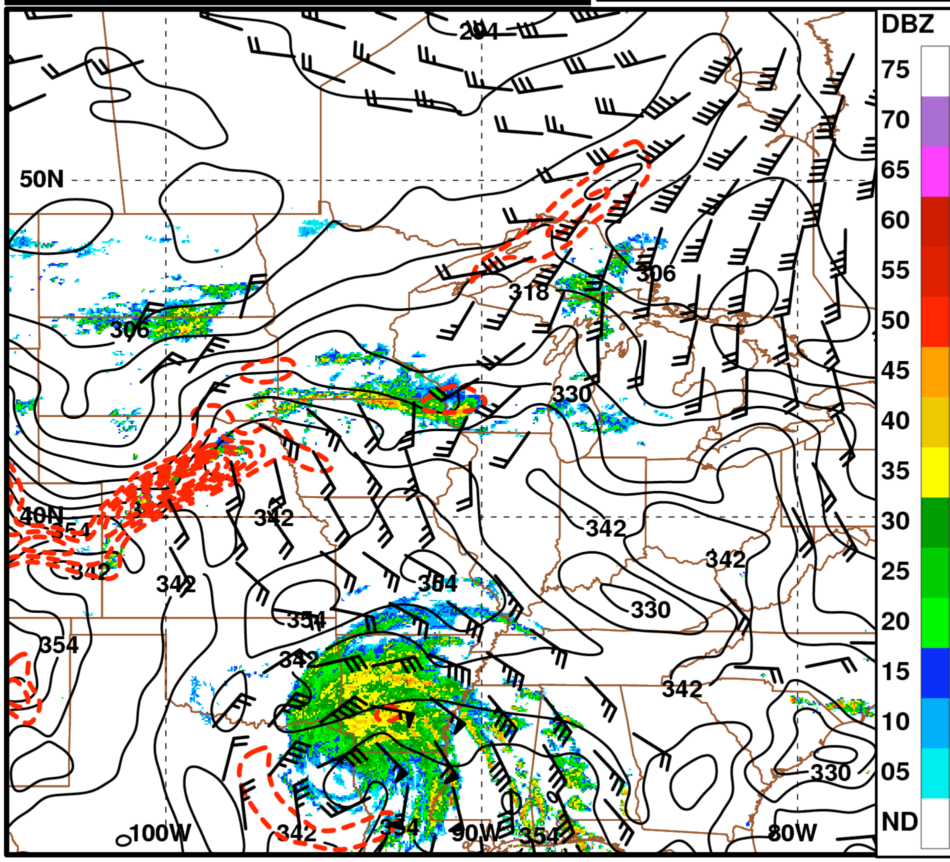
200 hPa *Z* (dam, black), wind barbs (≥25 m s^{-1}, barbs), wind speed (>35 m s^{-1}, shaded)

925 hPa *Z* (dam, black), θ (K, red), wind barbs (≥10 m s^{-1}, barbs) total precipitable water (>30 mm, shaded)

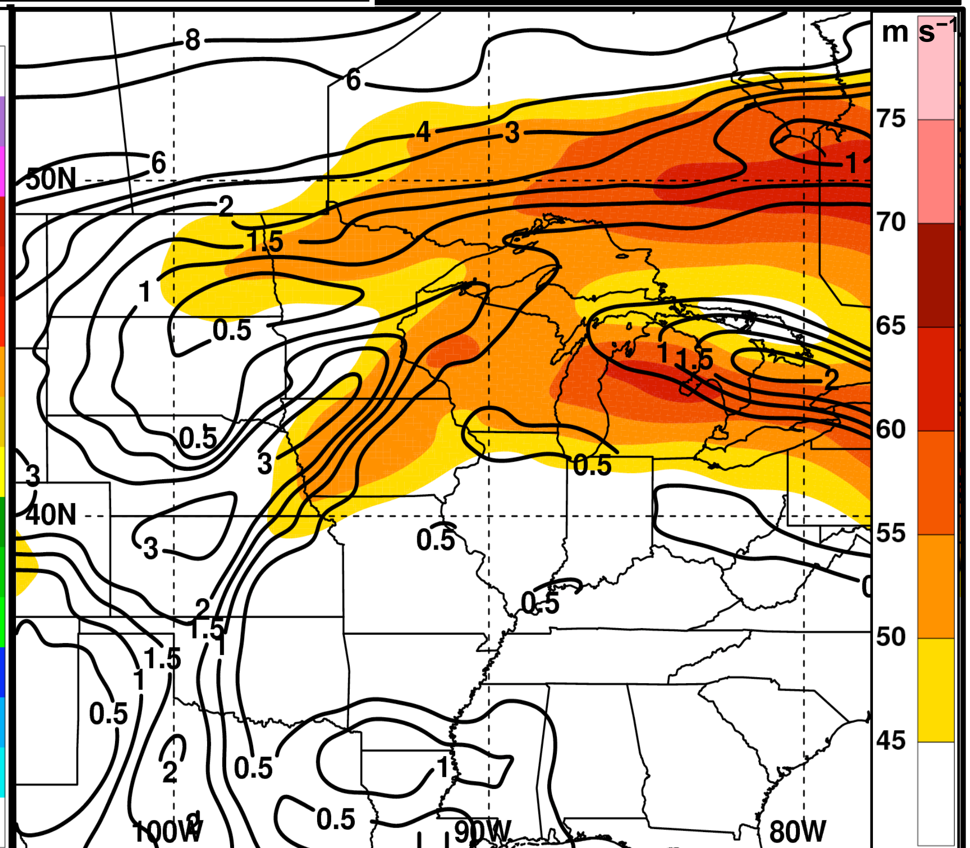
1º GFS Analysis

Mechanisms for Heavy Rainfall

0000 UTC 25 Sep



WSI NOWRAD reflectivity (dBZ); 925 hPa wind barbs (≥10 m s^{-1}), θ_e (K, black), frontogenesis [K (100 km)$^{-1}$ (3 h)$^{-1}$, red]

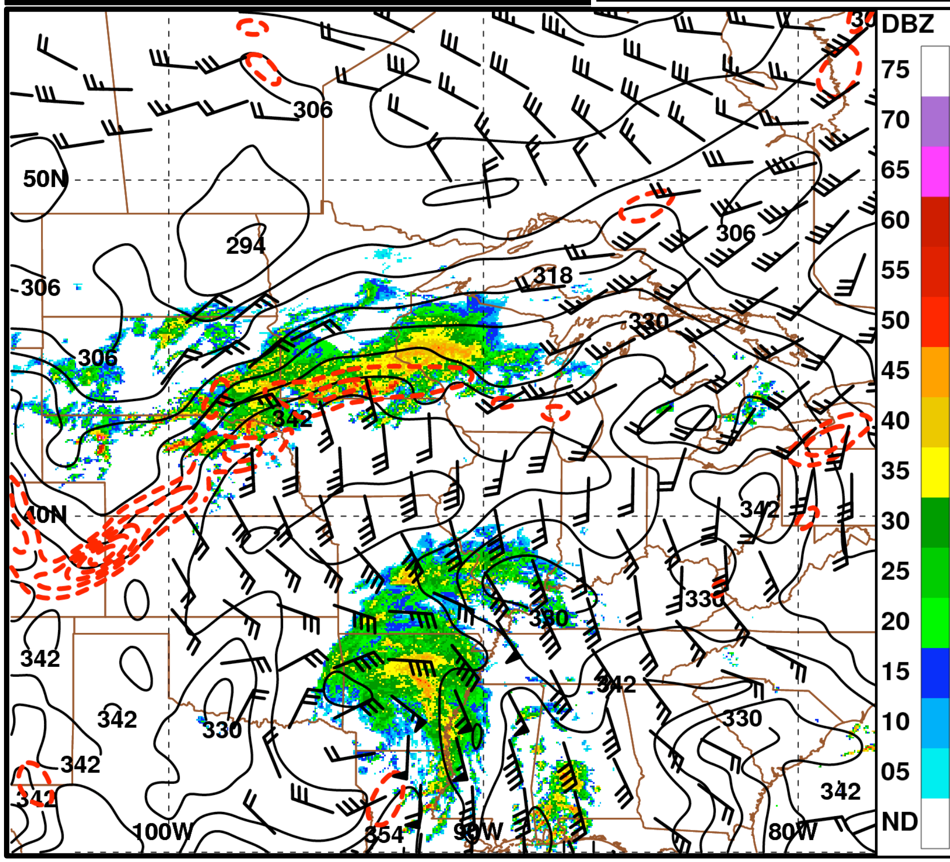


200 hPa wind speed (>45 m s^{-1}, shaded), PV (PVU, black)

20 km RUC Analysis

Mechanisms for Heavy Rainfall

0600 UTC 25 Sep



WSI NOWRAD reflectivity (dBZ);
925 hPa wind barbs (≥10 m s^{-1}),
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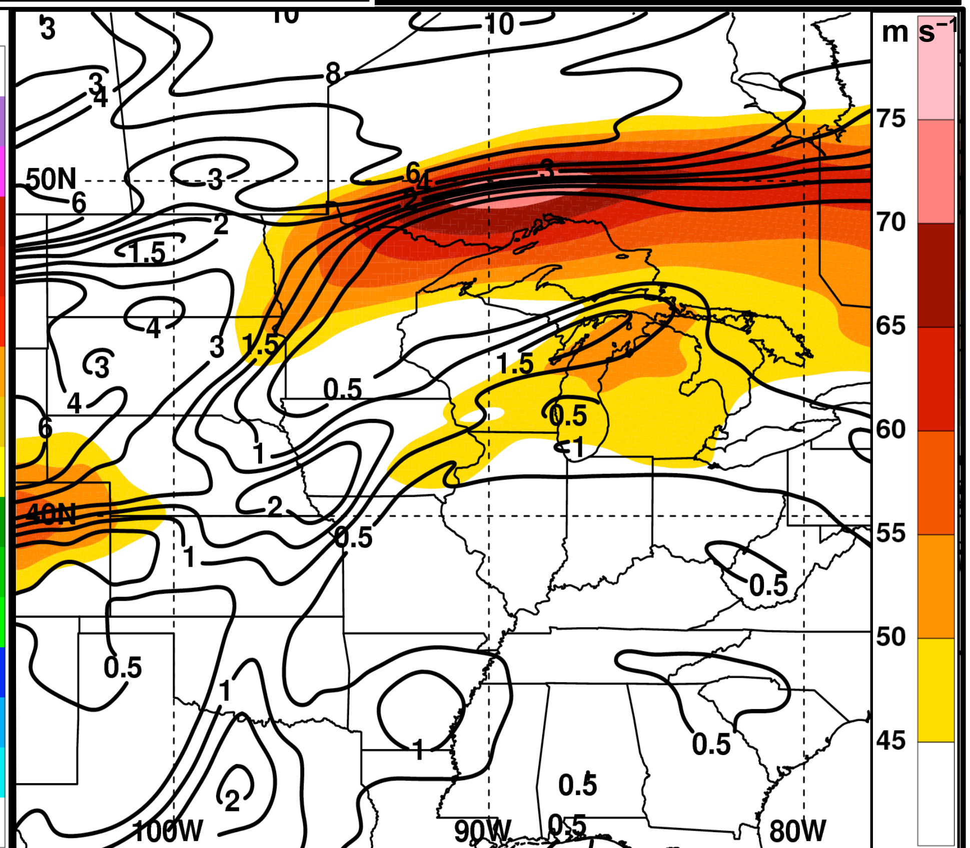
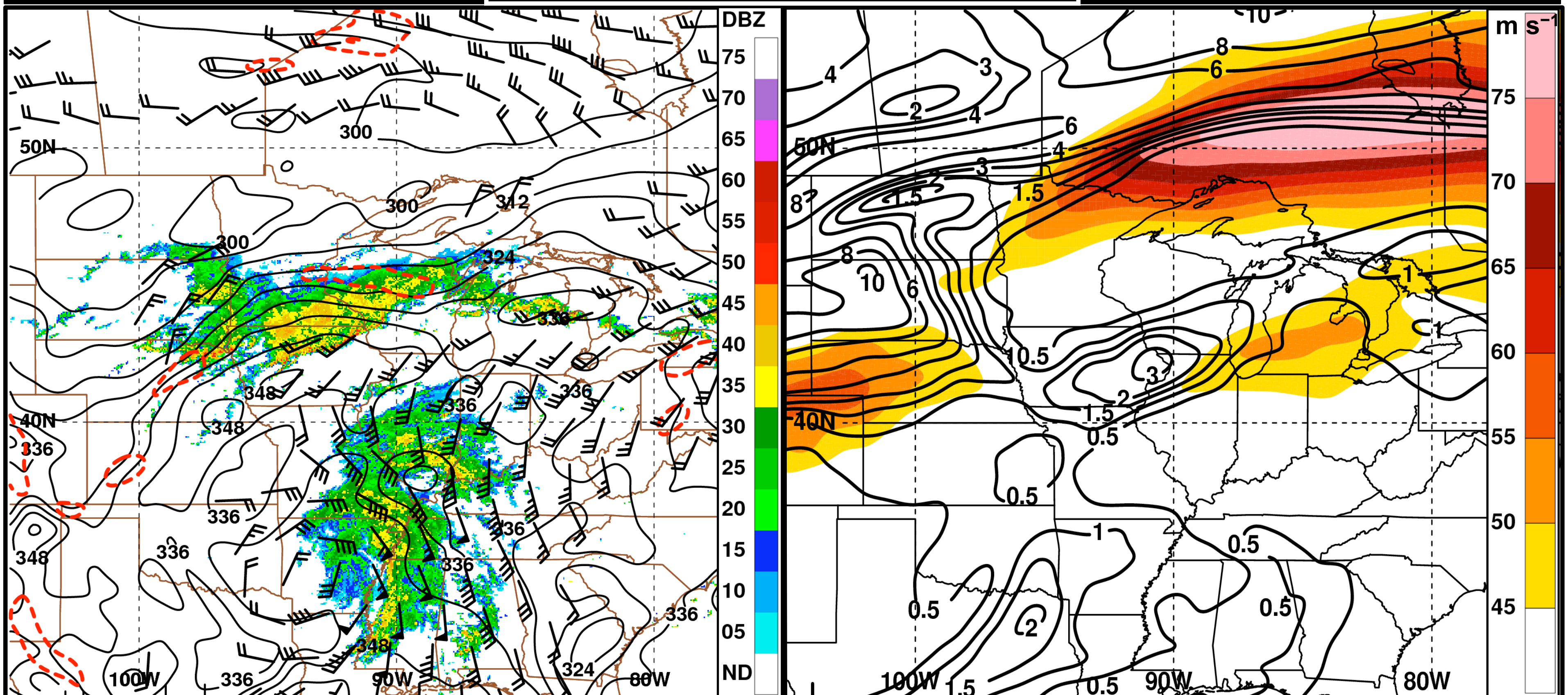


200 hPa wind speed (>45 m s^{-1}, shaded),
PV (PVU, black)

20 km RUC Analysis

Mechanisms for Heavy Rainfall

1200 UTC 25 Sep



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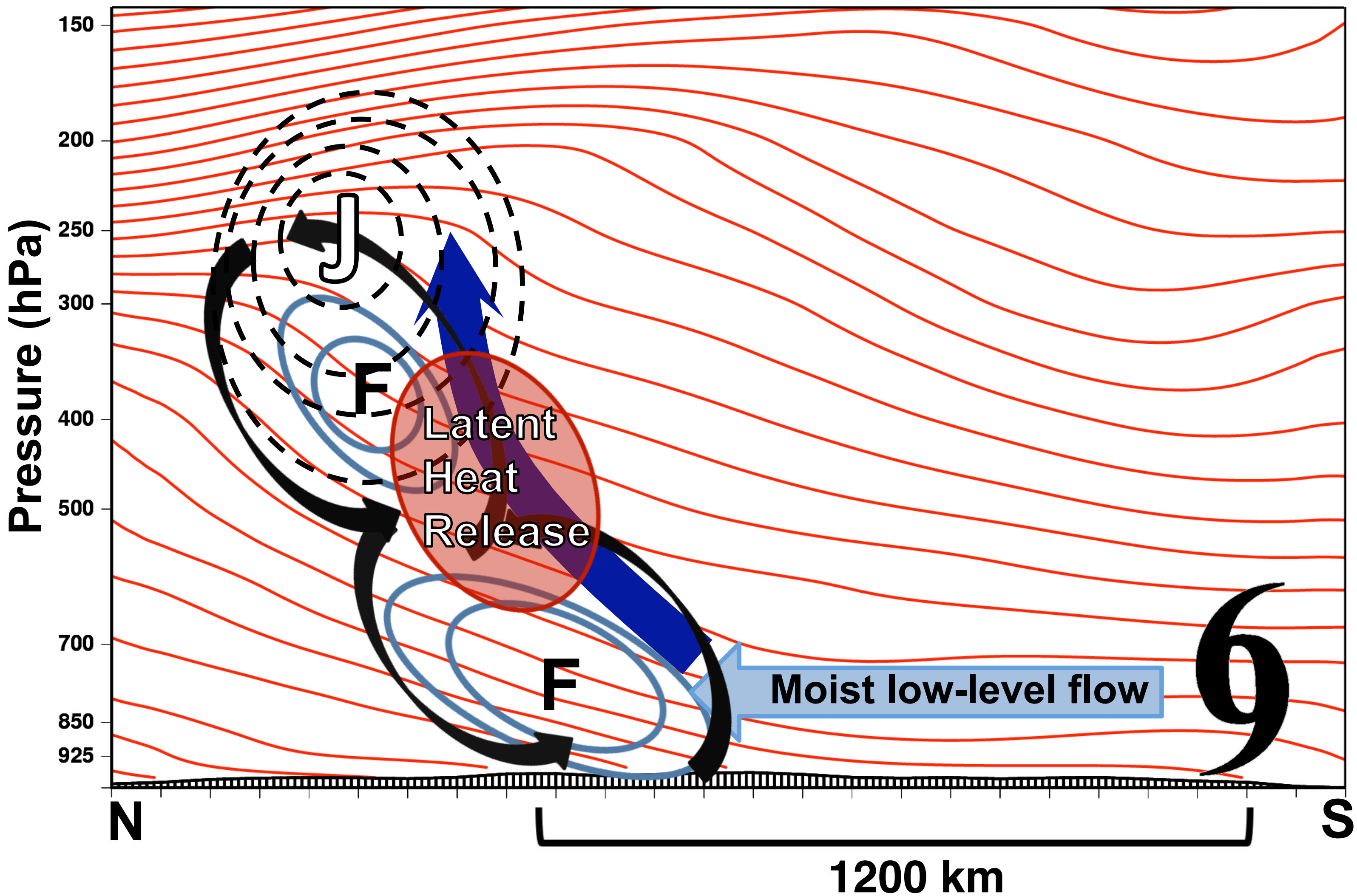
200 hPa wind speed (>45 m s^{-1}, shaded), PV (PVU, black)

20 km RUC Analysis

Schematic Depiction of the Rita PRE



Concluding Remarks

Key features of composites

- PREs preferentially develop in equatorward entrance region of an upper-level jet streak
- Strong low-level flow downstream of TC oriented perpendicular to baroclinic zone → warm air advection, frontogenesis, moisture transport from the TC
- Categories differ with regard to:
  - Position of TC relative to key features (i.e., trough, jet, ridge, baroclinic zone)
  - Amplitude and configuration of upper-/middle-tropospheric flow
  - Degree of the interaction between the TC and the midlatitude flow

Concluding Remarks

Rita case summary

- PRE developed as continuous, strong poleward moisture surge from Rita impinged upon a quasi-stationary baroclinic zone
- Low-level convergence and deformation at the terminus of the southerly low-level jet likely enhanced frontogenesis along baroclinic zone

Concluding Remarks

Rita case summary

- Upper-/middle-level diabatic heating in the mature PRE likely eroded PV aloft, promoted frontogenesis, and contributed to the strengthening of upper-level jet

- Long-lived PRE was likely due to a combination of:
  1. Continuous moisture transport towards and moisture convergence within PRE region
  2. Quasi-stationary region of low-level frontogenesis
  3. Diabatically enhanced secondary circulation within upper-level jet entrance region